Investigating the mechanical behaviour at a core-sheath interface in peripheral nerves

Conference or Workshop Item

European Cells and Materials Vol. 4. Suppl. 2, 2002 (pages 19-20) ISSN 1473-2262

INVESTIGATING THE MECHANICAL BEHAVIOUR AT A CORE-SHEATH INTERFACE IN PERIPHERAL NERVES

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INTRODUCTION: Knowledge of peripheral nerve anatomy has advanced using histological and microscopic techniques [1], whilst the tensile properties of peripheral nerves have also been investigated [2]. However, the way in which intraneural layers interact and behave mechanically is poorly understood. Movement between intraneural elements is essential during limb movement [3], and is disrupted by trauma. Regeneration of this gliding function will be essential for successful neural tissue engineering and the aim here is to define the important parameters of normal gliding function. Previous work by this group [unpublished] has demonstrated one such mechanically distinct layer, between an inner neural core and outer sheath, in rat sciatic nerve

METHODS: Sciatic nerves were harvested from Wistar rats (200-250g) immediately post mortem and mounted between two clamps, placed 15mm apart. The distal sheath was sutured to the distal clamp and the proximal sheath was cut circumferentially. This secured core to the proximal clamp and sheath to the distal clamp. In a tensile testing machine, traction was applied to the proximal core, pulling core from sheath. Force was measured using a 10N load-cell and core movement monitored using a linear voltage differential transformer. Using an extension rate of 10 mm/minute, a force/extension (pull-out) curve was obtained for each nerve. The movement of core and sheath was videoed for digital image analysis. After nerves had been mechanically tested they were fixed, for scanning electron microscopy. For comparison, strength of core within the sheath was also measured.

RESULTS: As the nerve unit as a whole takes up load, a large amount of force is required to produce a small increase in length (a) *(Figure 1)*. The “maximum pull-out force” occurs when the force applied to the core exceeds the break strength of linking elements between core and sheath. Once linkages break, the core began to glide out of the sheath (b) requiring decreasing amounts of force to maintain a constant increase in length. The mean maximum pull out force was 0.41 ± 0.04N (n=9). Video analysis appeared to demonstrate that sheath stretched by a small amount and then returned to its original length, whilst core underwent a permanent increase in length. The force required to break the core (reinforced by sheath) was 0.63 ± 0.06N (n=6).

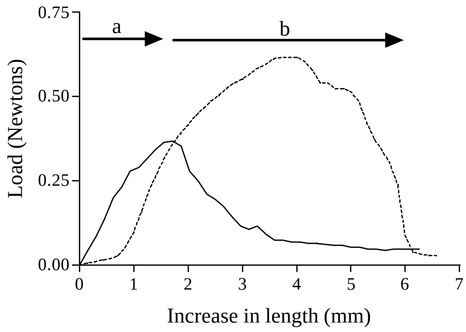

Figure 1. A graph demonstrating representative force-extension curves for core pulling out of sheath (solid line) and core breaking (broken line), for a 15 mm length of rat sciatic nerve

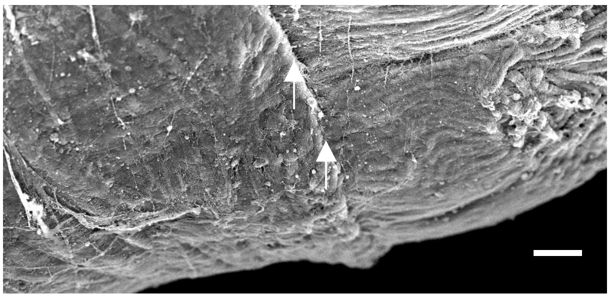

Fig. 2: Scanning electron micrograph of pulled rat sciatic nerve. Arrows indicate the edge of an outer sheath (left), as inner neural core (right) is pulled from it. Scale bar = 100 ìm

DISCUSSION & CONCLUSIONS: A mechanically distinct interface, with consistent mechanical properties, between two layers of peripheral nerve has been identified. A resistance to movement, which can be overcome using a mean force of 0.41 N, exists. This force is smaller than the forces required to break the whole nerve or its components. The resistance to movement could be produced by connecting elements, which break sequentially as the maximum pull-out force is obtained. Once sufficient numbers have fractured, the core can glide out of the sheath. This mechanism could act to protect the neural core from trauma and its imperfect regeneration would contribute to poor functional recovery.

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ACKNOWLEDGEMENTS: This work was partly supported by the European Commission grant: QLK3-CT-1999-00625.